

superstition, 'unexplained mysteries'; too ready credulity; tendency to magnify the importance of coincidence.

IV. Respect for another's point of view, an open-mindedness and willingness to be convinced by evidence.

V. Sensitive curiosity concerning reasons for happenings, coupled with persistence until the real reasons have been found."

A true appreciation and a steady utilization of these five characteristics will be possible to those who can accept the fundamental axiom with which this paper opened.

H. G. PICKETT

GENERAL SCIENCE TEACHING IN VIRGINIA TODAY

(II)

THIS article is a continuation of the study of the status of general science instruction in Virginia today, the first study having been published in the *VIRGINIA TEACHER* for October, 1928 (p. 237-243). The article contains the following sections: I. Survey (partial) of General Science courses given in Virginia, II. The Training of the General Science Teacher in Virginia, III. General Science Textbooks, IV. The Harrisonburg Water System: A Project in General Science, V. The Laboratory for General Science and Other Sciences, VI. Ways to Create Interest of Pupils in General Science, VII. How Modern Courses in General Science Carry Out the Seven Cardinal Principles, VIII. Conclusions.

The material for the above sections was worked out for the most part by groups of students¹ in a course in General Science

¹The following members of a class in the Organization of General Science co-operated in the preparation of this article: Mary Louise Blankenbaker, Mae Bass, Elizabeth Cockerill, Ethel M. Crown, Elizabeth Davis, J. Eugenia Eley, Mary Greene, Alice V. Nuckols, Olga M. Petterson, Elsie H. Quisenberry, Mrs. Christine L. Rodes, Elsie Shelhorse, Ruby A. Stewart, and Catherine E. Yancey.

given in the Fall Quarter, 1928, at the State Teachers College, Harrisonburg, Va.

The O'Shea Survey Report² has indicated several places in the educational system of the state which need improvement or change in order that the system may be on a par with the more progressive states of the Union. Since some of the aspects which need improvement concern science and the "scientific attitude," it seemed appropriate to study the general problem of teaching the most fundamental of the high school sciences (general science), keeping in mind both the discovery of the best modern practice, and the actual conditions and needs of the state.

A few extracts from the O'Shea Report may not be amiss here, as suggesting the importance of the right kind of science instruction; "Virginia has emphasized verbalism and symbolism rather than realism"; "Virginia education, taken as a whole, but allowing exceptions, is not dynamic. It is not designed to make pupils either interested in or capable of dealing with the material or sociological conditions surrounding them"; "In school and in college they (pupils and students) employ the faculty of memory largely rather than scientific reasoning or creative imagination"; "In the lower schools there has not been until recently any study of nature, and there is only a negligible amount of such study now. In the higher institutions science has occupied a subordinate place. So far as it has been possible for the survey staff to analyze the interests and the modes of thinking of the people of Virginia, it appears that they are not as a people scientific-minded."

I

Survey (Partial) of General Science Courses Given in Virginia in 1927-28

The members of the general science class

²M. V. O'Shea—Report to the Educational Commission of Virginia of a Survey of the Public Educational System of the State, Richmond, 1928.

interviewed 65 students at the Harrisonburg State Teachers College, Fall Quarter, 1928, in order to find out how many high schools taught general science, how much time was given to it, and the textbooks which were used. It was found that out of 65 accredited schools investigated 62 offered general science either in the 1st year (8th grade)

one school using Wood and Carpenter, one using Hessler, and the others were using Clark's *Introduction to General Science*. The two latter are the state-adopted texts.

A similar study to the above was made of the general science courses in all the high schools of one county in the central part of the state. The results are shown

TABLE I
SURVEY OF GENERAL SCIENCE COURSES IN HIGH SCHOOLS OF ONE COUNTY IN VIRGINIA
(A County Between Richmond and Staunton)

A. Accredited	No. of Pupils	Grade in which General Science is taught	Recitations per week	Lab. periods per week	Other Science Taught
School 1	?	1st yr. H. S.	5-60 minute	5-60 minute	Biology Chemistry
2	113	1st yr. H. S.	3-60 minute	2-60 minute	Biology Chemistry
3	35	1st yr. H. S.	3-60 minute	2-60 minute	Biology Chemistry
4	49	2nd yr. H. S.	3-60 minute	2-60 minute	Biology Chemistry Physiology and Hygiene
5	60	1st yr. H. S.	3-60 minute	2-60 minute	Biology Chemistry Geography Physiology Hygiene
6	45	1st yr. H. S.	3-60 minute	2-60 minute	Biology Chemistry
7	75	1st yr. H. S.	3-40 minute	2-40 minute	Biology Chemistry
B. Unaccredited					
8	13	none			Only 1 yr. of work
9	8	1st yr. H. S.	5-40 minute		1 yr. of work

or 2nd year, and in a few cases, in other years. In most cases 3 periods of recitation and 2 double periods of laboratory per week were given. In some schools there is no laboratory and 5 periods are devoted to recitation, while in a few others, 4 recitation periods and 1 laboratory period is the plan.

The other sciences were rather uniform in all the schools. Out of the 65 accredited schools, 62 taught biology, 56 chemistry, and 25 physics. The reason why more general science is taught is probably that general science is a required subject in most schools, while the other sciences are elective, except biology, which is a state-required subject.

With reference to textbooks, there was

in Table I. In this county, we observe that general science is taught in all seven accredited high schools, and that biology and chemistry are likewise taught in the same seven institutions.

It would be desirable to have physics also offered in the high schools of the state on account of its value to agriculture, domestic science, industry, and for general culture. It could be offered alternately with chemistry to third and fourth year students. The cost of apparatus is not excessive if the state minimum requirements are followed.

II.

The Training of General Science Teachers

Information was secured concerning the science preparation of all the teachers of

science in one county in the Shenandoah Valley. With these data in hand, comparison was made among the science teachers, and the results are given in Table II.

Table II shows the preparation of eleven teachers as far as science courses are concerned. We find that two of the eleven teaching general science are prepared only in either biology or chemistry. We find five teaching general science who are prepared in only two sciences. These facts indicate that several of the science teachers in this county are inadequately prepared to teach general science, because a general science teacher, according to modern standards, should have had at least one good college course in biology, chemistry, and physics. Frank³ lists the following "content" science courses as requisite for a first class teacher of general science; chemistry (1 year), physics (1 year), botany (1 semester), zoology (1 semester), physiology, sanitation and hygiene (1 semester), geography and geology (1 semester). It is clear therefore that the standards of preparation for these teachers should be raised.

³Frank—"How to Teach General Science" (1926), pp. 183.

Fortunately, the State Board of Education is gradually raising the requirements for high school teachers. Beginning in September, 1929, teachers will be required to have four years of college training instead of two as formerly. But, in addition to the increase in years of study, the standards for science teachers in Virginia should be decidedly higher, and there should be a definite increase in the number of science courses taken.

At present a student in a state teachers college who is majoring in science is required to complete 36 quarter-hours (24 semester hours) of work in the sciences. It would be better to separate the sciences, and arrange for a major in any one of them, e. g., in chemistry, biology, physics, or general science, together with a minor in one or two of them. The number of quarter-hours to be required for a major and a minor could be worked out after a thorough canvass of the best practice elsewhere, but, in any case, the amount of required content work should be more than at present. If this is done, the graduates of the state teachers colleges would be prepared decidedly better in the subject-matter which they

TABLE II
PREPARATION OF HIGH SCHOOL SCIENCE TEACHERS IN ONE COUNTY IN VIRGINIA (IN THE SHENANDOAH VALLEY)

	Teachers	Science courses taken in college or in graduate work			Science courses being taught
		Biology Sem. Hrs.	Chemistry Sem. Hrs.	Physics Sem. Hrs.	
1.	(B. S.)	12	16	4	Chemistry
2.	no degree	6	6	..	{ General Science Biology
3.	(B. A.)	8	{ General Science Biology, Chemistry
4.	no degree	..	20	..	General Science
5.	(B. S.)	..	8	..	{ Biology Chemistry
6.	(B. S.)	30	24	16	{ General Science Chemistry
7.	(B. A.)	13	8	..	Biology
8.	(B. A.)	8	8	..	Biology and Chemistry
9.	(B. S.)	12	24	12	{ General Science Biology and Chemistry
10.	(B. S., A. M.)	45	6	..	{ General Science Biology
11.	(B. S.)	37	29	10	{ Biology, Chemistry and Physics

are to teach, and a distinct improvement over the present situation would be brought about.

The above proposal is in accord with a more comprehensive one (unpublished) suggested about a year ago by Dr. Hall and Mr. Eason of the Virginia State Board of Education to various institutions in the state. Their idea as applied to the natural sciences was that students preparing to teach high school sciences should take more work in the subject matter of the sciences, and somewhat less in education.

Another aspect of the problem of training science teachers has to do with supervised teaching which is required of all students in the state teachers colleges before a professional certificate can be obtained. Close correlation should exist between supervised teaching and the "organization and teaching" courses. The ideal plan would be to require a student-teacher to carry on practice teaching of his major course under the direction of an instructor, who could, in addition to co-operating in the supervision of the teaching, give the necessary instruction in the content side of the subject.

III

Survey of Modern Texts

Thirteen text-books of general science were scored according to Frank's criteria³ and the results studied in table form as in the previous study (See THE VIRGINIA TEACHER, October, 1928, p. 241). According to these criteria there is a wide variety in the quality of textbooks. The eight texts which made the highest score are listed below, but not in order of the score:

1. Caldwell and Eikenberry—Elements of General Science
2. Clement, Collister and Thurston—Our Surroundings
3. Peiper and Beauchamp—Everyday Problems in Science

³Loc. cit.

4. Webb and Didcoct—Early Steps in Science
5. Wood and Carpenter—Our Environment
6. Hunter and Whitman—Civic Science in Home and Community
7. Bowden—General Science
8. Van Buskirk and Smith—Science of Everyday Life

Every progressive teacher of general science will make certain that he has several of these excellent texts constantly at hand for reference. Several should also be secured for the high school library, for the use of the students, to supplement the state-adopted texts. All teachers should be interested concerning the state adoption of texts, until this vexed question is settled right. Those who are interested in the subject will find a helpful discussion in a pamphlet by Cubberly, published in March, 1927, entitled "The School Textbook Problem." It is sent free to those who write for it. Address: Houghton Mifflin Co., 2 Park Row, Boston, Mass.

IV

The Harrisonburg Water System: A Project in General Science

(This section is printed separately as an article elsewhere in this issue).

V

The Laboratory for General Science and Other Sciences

Since in Virginia high schools finances are so limited that economy has to be practised, it is fortunate that general science laboratories may be begun with almost no equipment. Very few high schools need more than a single laboratory for each of the four high school science subjects: chemistry, physics, biology, and general science. In all but very large schools the general science class may well use the other laboratories, particularly the biology laboratory. Smaller schools often use a single laboratory for physics and chemistry, and another laboratory for biology and general science,

and in still smaller schools where there are but three or four classes in all the sciences, a single laboratory for all will suffice, provided it is equipped with special furniture for students' desks, and with sufficient cabinet and storage room, for apparatus, equipment, and supplies.

Studies made in many high schools show that few laboratories are used to their capacity. Dr. P. C. Parker in a recent study in the high schools of New York City found that the chemistry laboratories were idle 50% of the time; physics 71%; and the biological laboratories 44%. This waste is particularly noticeable in smaller schools. Recent studies show that not over one science is, or need be, given at any one time. On the days when science classes are scheduled for classroom recitation, and for lecture demonstration, the laboratories, in most cases, are not in use at all. For all the one-science-teacher schools a single laboratory specially equipped is sufficient and is a considerable economy in space and in building cost.⁴

The laboratory furniture must be well constructed. Its construction involves many points not understood by anyone except those who have made a special study of the subject.

Laboratories should be fitted with students' desks 30 inches high; a demonstration table for the instructor and chairs for pupils should be provided in case the classroom recitations and demonstrations are held in the same room, with the pupils seated at their tables. The long narrow tables with pupils only on one side are preferable.

Cabinets⁵ for specimens and apparatus, chemicals and other equipment are necessary unless a storage room is provided.

The general science laboratory needs a

broad range of inexpensive and simple apparatus, though no great quantity in any one field. In many cases instead of ready-made instruments, the materials out of which these can be made are more to be desired.

Some teachers who have been handicapped by lack of apparatus have found it possible to get interested people to donate a few tools with which the class can make a number of valuable pieces of apparatus for permanent use.

The ambitious teacher would do well to visit the local junk yard where many worthwhile materials can often be obtained for a few cents. Automobile parts, pumps, valves, and tools of various kinds will often be found. And the ten-cent store should not be overlooked as a source of material usable in general science classes.

VI

Ways to Create Interest of Junior High Pupils in General Science

- I. There should be many experiments for a junior high school pupil.
Advantages of experiments to junior high school pupils:
 1. Experiments create interest in class-work.
 2. Experiments thoroughly teach facts and principles when guided carefully by the teacher.
 3. Experiments stimulate interest for research.
- II. Experiments should be performed by the pupils.
Manipulation of apparatus places pupil in scientific world and assures him thorough training.
- III. Demonstration experiments have proven successful in junior high school. Pupils should help set up apparatus and perform experiments when possible.
- IV. Experiments should always be written up by the pupils.
 - A. They should be shown the importance of writing up experiments.

⁴Monahan—Laboratory Layouts for the High School Sciences, Bulletin 1927, No. 22. U. S. Bureau of Education, 15 cts. (Very valuable).

⁵Laboratory Equipment for Science Instruction in High Schools of Virginia, Richmond, 1924. Superintendent of Public Printing.

B. A simple outline like the following should be used in writing up experiments:

1. Why we performed this experiment.
2. What we used in performing this experiment.
3. What we did.
4. What happened.
5. What we learned.

V. Have excursions to places of interest in the city or community.

A. Excursions made by

1. the whole class
2. a designated committee
3. individuals.

B. Teacher directs excursions.

C. Information desired always decided upon by class before excursion is made. Note—teacher directs selection of the above.

D. It is well to have one pupil of outstanding ability on each committee.

E. Pupils will always make reports of information gained.

- a. Teacher guides discussion in class room after excursion.
- b. Pupils are always encouraged to ask worthwhile questions of the committee or teacher.

Note—This is excellent training in clearcut thinking.

F. Collections should be made by the pupils while on excursions.

G. Have exhibits of things collected or made by the class.

- a. Invite patrons to the exhibit.
- b. Let pupils demonstrate how the things they made will work.

Note—This will make patrons terested in what is going on in school. Incidentally, exhibits will also help to educate parents.

VII

How Modern Courses in General Science Carry Out the Seven Cardinal Principles⁶

Bagley, Inglis, Eikenberry, and other educators⁷ have made plain to the average teacher just how the work in science should be made to contribute definitely to the seven well-known cardinal objectives.

In this article we shall attempt to consider these objectives, and show how general science makes a large contribution toward their attainment.

1. *Health.* Since the conservation of the individual's health is more important than all else, the teaching of the laws of health should form a vital part of general science. It is this science that teaches the basic principles of public sanitation and personal hygiene, upon which depends the control and elimination of disease, the provision of medical inspection, and the maintenance of public health. For example these basic principles are brought out in teaching the child; first, how to protect himself from micro-organisms; second, how to control the factors regulating body temperature; third, how to maintain body cleanliness, external and internal; fourth, how to care for the teeth, eyes, ears, nose, etc. The teachers will find it quite valuable to keep score charts of all the pupils who brush the teeth and clean the nails, daily. This is a stimulus for the foundation of good health habits. The value of health teaching cannot be overestimated, and general science teachers are urged to get helpful aids from (1) The State Board of Health at Richmond, Virginia, (2) The American Child Health Association, New York, N. Y. (3) *Thirty Lessons in Health*—prepared for

⁶a. *Reorganization of Science in Secondary Schools*, Bulletin 1920, No. 26, U. S. Bureau of Education.

b. Downing—*Teaching Science in the Schools*.

c. Trafton—*The Teaching of Science*.

⁷Frank—*How to Teach General Science*—p. 35.

rural schools of North Dakota—State Department of Education, Bismark, N. D.

2. *Command of Fundamental Processes.*

General Science stresses inductive thinking through problem solving. It is science that first urges pupils to form the habit of drawing correct conclusions from observed facts. In the laboratory they carry these conclusions over into action and learn the truths of science. From the understanding of fundamental laws and principles of science they gain the power to reason which gives them a scientific attitude of mind that is valuable in the solution of life's problems and in independent thinking. This scientific attitude should include the following points: curiosity, open-mindedness, a habit of weighing evidence, and a belief in the law of cause and effect.

3. *Worthy Home Membership.*

General science touches the efficiency of the home and life within the home at every angle. It is a strong force in relation to intelligent home-making, management, and enjoyment. It is the teaching of general science that leads the pupil fully to appreciate the modern conveniences which make his home happy and comfortable. This knowledge carries over into the practical life of the home and enables each member to contribute something to its betterment. This applies to such members of the family as may be called upon to make repairs to the heating, lighting, plumbing, and ventilating system or to perform any of the services that have to do with the care of the home.

4. *Vocational Guidance.*

General science gives a taste of the various branches of science, such as mechanics, electricity, industrial and household chemistry, and various applied sciences. Such knowledge tends to give the pupil a background for selecting his vocation. A knowledge of the underlying principles arouses interest and results in helping the

pupil to find the particular vocation for which he is suited.

5. *Citizenship.*

By the acquisition of scientific knowledge ideals of citizenship are established. General science furnishes unlimited opportunity to show pupils how they may best perform their social duties and how to co-operate with others to promote the best welfare of the community. For example, boys and girls are taught the necessity of the preservation of birds and forests, the necessity of keeping the water supply pure and controlling pests and insects, which injure community health.

6. *Wise Use of Leisure Time.*

General science teaching sets the pupil to thinking and introduces to him many useful and pleasurable avocations. For example, he may study nature, grow flowers and vegetables in his home garden, or care for some pet. He may spend his leisure time on photography or radio. General science also employs methods that arouse interest in studying raw materials, visiting museums, etc. These interests will carry over into later life.

7. *Ethical Character.*

It is in the study of general science that the pupil is first impressed that science exalts the truth. He then establishes a clearer conception of truth and a belief in the law of cause and effect. Laws thus established give the pupil a sound method of solving life problems. In this way character is strengthened.

VIII

Conclusions

As a result of the two studies on general science teaching in Virginia today the following suggestions are offered for the consideration of teachers and others interested in science education in the state:

(1) That general science be made a required study for the first year of the four

year high school, (or the equivalent grade for a junior high school), to be followed by a year of required biology.

(2) That certification regulations for science teachers be altered and that certificates be no longer issued for high school science in general but for *each science* for which certain qualifications are met. For instance, the requirements for a general science teacher would be at least one year of each of the following college courses: biology, chemistry, physics, mathematics, and a half year of physiology and hygiene, and for a chemistry teacher, the requirements would be 2 (preferably 3) years of college chemistry, and one year of each of the following: physics, biology, and mathematics. Such regulations would represent a distinct advance over the present situation.

(3) That the number of adopted textbooks of general science be increased from two to five, and that the list of five books be revised every two years.

(4) That the State Board of Education be requested to revise its bulletin on Laboratory Equipment for Science Instruction (Vol. VII No. 1, July, 1924), including in the revision such valuable recent material as that contained in Monahan's *Laboratory Layouts for High School Sciences*.

(5) That the State Board of Education be requested to appoint a committee of science teachers to study the Natural Science courses at present offered in the elementary and high schools of the state, and to recommend such changes in the courses, laboratory equipment, preparation of teachers, etc., as will best meet the modern industrial, agricultural, and cultural needs of the state.

FRED C. MABEE AND OTHERS

Teacher: "What is 'average'?"

Small Pupil: "A thing to lay eggs on."

Teacher: "What makes you say that?"

Small Pupil: "Well, my mother says that our old hen lays six eggs a week on an average."

HINTS FOR THE HIGH SCHOOL TEACHER OF GEOMETRY

FOR MANY years the writer was a teacher in secondary schools and always the hardest task he had was the teaching of geometry. The task was somewhat lightened after he became familiar with some of the facts of modern geometry and projective geometry which came to him as part of a course leading to the Ph. D. degree in mathematics. But there was something yet lacking in his preparation for teaching high school geometry.

An illustration will show the difficulty perhaps better than any amount of explanation. Take the theorem given in practically all textbooks in geometry, "If two triangles have two sides of the one equal respectively to two sides of the other, but the included angle of the first greater than the included angle of the second, then the third side of the first is greater than the third side of the second." (If you are good at visualizing, try this in your head; if not, get a piece of paper and pencil and draw as you read.)

Draw two triangles ABC and DEF such that AB is equal to DE, and BC is equal to EF, but the angle ABC is greater than the angle DEF. Although it is not usually done in the textbooks, I suggest that you draw another triangle exactly equal to ABC as a basis for the figure upon which you are to base your proof. We now wish to prove AC is greater than DF.

Using the second triangle ABC lay the triangle DEF on it in such a way that D falls on A, and E on B then the line EF will fall inside the angle ABC and F will in general fall across AC from B. The proof usually given is: Bisect the angle FBC and produce the bisector to cut AC at H. Join H to F, then in the triangles BHF and BHC, BH is equal to BH identical, FB is equal to BC. hyp. and angle FBH is equal to HBC const. Therefore,